

SUPPLEMENTAL MATERIAL

Details of Measurement Error Model

The original analysis used daily county-level exposures for each of the components of PM_{2.5} which were defined as the trimmed mean of all available observations from monitors in that county on a particular day. In order to explore the potential effects of spatial heterogeneity in the components, we conducted an alternate analysis. For each component, we first estimated the spatial variability of the component using all pairs of monitors in the STN that were less than 150 miles apart. Using these pairs of monitors we could estimate the variogram of the pollutant process on each day. These daily variograms were then averaged across time to produce a single variogram for each component of PM_{2.5} which captures the spatial variability of the component as a function of distance. Using a classical measurement error model, we assumed that the observed value of a component was equal to the true county-wide average plus noise. If W_{kt}^c is the observed value of the k th component ($k = 1, \dots, 7$) on day t in county c , and X_{kt}^c is the true county-wide average of component k on day t in county c , then we assumed that $W_{kt}^c = X_{kt}^c + U_{kt}^c$, where U_{kt}^c is the county-specific measurement error for component k which has mean 0 and constant variance estimated from the variogram for component k . Let σ_{kc}^2 be the county-specific measurement error variance for component k . Then we can use a simulation extrapolation (SIMEX) procedure (Carroll et al. 2006) to correct for the measurement error in the risk estimates. Briefly, we add noise to the observed values to create pseudovalues $W_{kt}^{c*} = W_{kt}^c + \sqrt{\zeta} U_{kt}^c$, where U_{kt}^c is a Normally distributed random variable with mean zero and variance σ_{kc}^2 . We then conduct the same analysis as the original but using the pseudovalues in place of the observed data. We

subsequently create new pseudovalues with more noise (i.e larger values of ζ) and refit the models. As the amount of noise in the pseudovalues increases, the estimates of the risk parameters decrease, creating a downward trend. This trend can be extrapolated backwards to produce an estimate of the risk parameters with no measurement error. We used a natural spline with 2 degrees of freedom for extrapolation. Statistical properties of the SIMEX procedure can be found in (Cook and Stefanski 1994).

Our original multi-pollutant analysis of EC and CVD admissions found that a 1 IQR increase in EC at lag 0 concentration was associated with a 0.80 (95% PI: 0.34, 1.27) percent increase in CVD admissions. Using the same 119 counties with the measurement error model, we obtained an estimate of a 1.11 (95% PI: 0.61, 1.60) percent increase in CVD admissions per IQR increase in EC. For OCM we originally estimated a 1 IQR increase in OCM at lag 0 was associated with a 1.01 (95% PI: 0.04, 1.98) percent increase in RESP admissions in a multi-pollutant model. The measurement error model estimated a 1.43 (95% PI: 0.38, 2.50) percent increase in RESP admissions per IQR of OCM at lag 0.

National Average Estimates

Cardiovascular Admissions (single pollutant)

Lag 0

	Estimate	Std. Error	2.5%	97.5%
SULFATE	0.43	0.23	-0.02	0.87
NITRATE	0.46	0.15	0.17	0.75
silicon	0.15	0.08	0.00	0.30
Elemental_Carbon	0.72	0.15	0.43	1.01
OC_K14	0.66	0.19	0.29	1.02
Sodium_Ion	0.01	0.08	-0.15	0.17
AMMONIUM	0.68	0.19	0.31	1.06

Lag 1

	Estimate	Std. Error	2.5%	97.5%
SULFATE	-0.20	0.21	-0.61	0.21
NITRATE	0.01	0.14	-0.27	0.28
silicon	0.05	0.09	-0.12	0.22
Elemental_Carbon	-0.08	0.16	-0.39	0.22
OC_K14	0.19	0.19	-0.18	0.56
Sodium_Ion	0.10	0.09	-0.08	0.28
AMMONIUM	-0.07	0.18	-0.43	0.30

Lag 2

	Estimate	Std. Error	2.5%	97.5%
SULFATE	0.07	0.23	-0.38	0.52
NITRATE	-0.08	0.15	-0.37	0.21
silicon	0.00	0.08	-0.16	0.15
Elemental_Carbon	-0.23	0.18	-0.59	0.13
OC_K14	-0.08	0.21	-0.50	0.34
Sodium_Ion	-0.04	0.09	-0.20	0.13
AMMONIUM	-0.08	0.19	-0.46	0.30

Cardiovascular Admissions (multiple pollutant)

Lag 0

		Std.		
	Estimate	Error	2.5%	97.5%
SULFATE	0.02	0.27	-0.51	0.55
NITRATE	0.25	0.17	-0.09	0.59
silicon	0.05	0.07	-0.08	0.19
Elemental_Carbon	0.80	0.24	0.34	1.27
OC_K14	-0.14	0.32	-0.76	0.48
Sodium_Ion	-0.02	0.06	-0.14	0.10
AMMONIUM	0.35	0.22	-0.08	0.79

Lag 1

		Std.		
	Estimate	Error	2.5%	97.5%
SULFATE	-0.30	0.24	-0.77	0.17
NITRATE	0.01	0.18	-0.35	0.37
silicon	0.04	0.08	-0.12	0.21
Elemental_Carbon	-0.40	0.20	-0.80	0.00
OC_K14	0.63	0.29	0.06	1.19
Sodium_Ion	0.06	0.07	-0.08	0.21
AMMONIUM	-0.09	0.19	-0.47	0.28

Lag 2

		Std.		
	Estimate	Error	2.5%	97.5%
SULFATE	0.17	0.26	-0.33	0.67
NITRATE	-0.07	0.19	-0.44	0.30
silicon	0.01	0.08	-0.14	0.16
Elemental_Carbon	-0.27	0.21	-0.68	0.14
OC_K14	0.21	0.29	-0.35	0.77
Sodium_Ion	-0.01	0.07	-0.15	0.14
AMMONIUM	0.03	0.09	-0.15	0.20

Respiratory Admissions (single pollutant)

Lag 0

		Estimate	Error	Std.	2.5%	97.5%
SULFATE		-0.33	0.40		-1.12	0.45
NITRATE		0.01	0.22		-0.43	0.44
silicon		0.08	0.14		-0.19	0.35
Elemental_Carbon		0.40	0.24		-0.08	0.88
OC_K14		0.83	0.31		0.22	1.44
Sodium_Ion		0.02	0.13		-0.23	0.27
AMMONIUM		-0.01	0.32		-0.63	0.61

Lag 1

		Estimate	Error	Std.	2.5%	97.5%
SULFATE		0.60	0.36		-0.10	1.30
NITRATE		-0.07	0.21		-0.49	0.36
silicon		0.03	0.16		-0.29	0.35
Elemental_Carbon		0.30	0.25		-0.19	0.78
OC_K14		0.28	0.31		-0.32	0.88
Sodium_Ion		0.17	0.14		-0.10	0.44
AMMONIUM		0.25	0.29		-0.32	0.82

Lag 2

		Estimate	Error	Std.	2.5%	97.5%
SULFATE		0.66	0.37		-0.07	1.40
NITRATE		-0.31	0.21		-0.73	0.11
silicon		-0.16	0.18		-0.51	0.18
Elemental_Carbon		-0.05	0.24		-0.53	0.43
OC_K14		0.52	0.31		-0.09	1.13
Sodium_Ion		0.09	0.13		-0.16	0.34
AMMONIUM		-0.05	0.29		-0.62	0.53

Respiratory Admissions (multiple pollutant)

Lag 0

		Std.		
	Estimate	Error	2.5%	97.5%
SULFATE	-0.64	0.46	-1.53	0.26
NITRATE	-0.12	0.26	-0.64	0.39
silicon	0.13	0.09	-0.05	0.31
Elemental_Carbon	0.01	0.41	-0.79	0.82
OC_K14	1.01	0.49	0.04	1.98
Sodium_Ion	-0.04	0.11	-0.26	0.18
AMMONIUM	-0.53	0.33	-1.19	0.12

Lag 1

		Std.		
	Estimate	Error	2.5%	97.5%
SULFATE	0.62	0.41	-0.17	1.42
NITRATE	-0.29	0.27	-0.82	0.24
silicon	0.07	0.14	-0.21	0.34
Elemental_Carbon	0.07	0.32	-0.56	0.70
OC_K14	0.31	0.46	-0.59	1.22
Sodium_Ion	0.12	0.11	-0.10	0.33
AMMONIUM	0.00	0.33	-0.64	0.64

Lag 2

		Std.		
	Estimate	Error	2.5%	97.5%
SULFATE	0.79	0.45	-0.09	1.66
NITRATE	-0.74	0.26	-1.24	-0.24
silicon	0.01	0.14	-0.25	0.28
Elemental_Carbon	-0.35	0.30	-0.94	0.24
OC_K14	1.08	0.49	0.12	2.04
Sodium_Ion	0.13	0.10	-0.07	0.33
AMMONIUM	-0.61	0.34	-1.27	0.06

119 Counties Used in Main Analysis

Jefferson, AL	Jefferson, KY	Lorain, OH
Madison, AL	Kenton, KY	Lucas, OH
Mobile, AL	E. Baton Rouge, LA	Mahoning, OH
Montgomery, AL	Baltimore, MD	Montgomery, OH
Maricopa, AZ	Prince George's, MD	Stark, OH
Pima, AZ	Baltimore (city), MD	Summit, OH
Pulaski, AR	Hampden, MA	Oklahoma, OK
Fresno, CA	Suffolk, MA	Tulsa, OK
Kern, CA	Kent, MI	Multnomah, OR
Los Angeles, CA	Washtenaw, MI	Allegheny, PA
Riverside, CA	Wayne, MI	Chester, PA
Sacramento, CA	Hennepin, MN	Dauphin, PA
San Diego, CA	Harrison, MS	Delaware, PA
Santa Clara, CA	Hinds, MS	Erie, PA
Ventura, CA	Clay, MO	Lackawanna, PA
Adams, CO	St. Louis (city), MO	Lancaster, PA
El Paso, CO	Douglas, NE	Northampton, PA
New Haven, CT	Clark, NV	Philadelphia, PA
District of Columbia, DC	Washoe, NV	Washington, PA
Broward, FL	Hillsborough, NH	York, PA
Escambia, FL	Rockingham, NH	Providence, RI
Hillsborough, FL	Camden, NJ	Charleston, SC
Leon, FL	Middlesex, NJ	Greenville, SC
Pinellas, FL	Morris, NJ	Richland, SC
Bibb, GA	Union, NJ	Davidson, TN
DeKalb, GA	Bernalillo, NM	Hamilton, TN
Muscogee, GA	Bronx, NY	Knox, TN
Richmond, GA	Erie, NY	Shelby, TN
Cook, IL	Monroe, NY	Sullivan, TN
DuPage, IL	New York, NY	Dallas, TX
Madison, IL	Queens, NY	El Paso, TX
Elkhart, IN	Buncombe, NC	Davis, UT
Marion, IN	Forsyth, NC	Salt Lake, UT
Vanderburgh, IN	Guilford, NC	Henrico, VA
Linn, IA	Mecklenburg, NC	King, WA
Polk, IA	Wake, NC	Spokane, WA
Scott, IA	Butler, OH	Kanawha, WV
Sedgwick, KS	Cuyahoga, OH	Milwaukee, WI
Wyandotte, KS	Franklin, OH	Waukesha, WI
Fayette, KY	Hamilton, OH	

Reference List

1. Carroll RJ, Ruppert D, Stefanski LA, Crainiceanu CM. 2006. Measurement Error in Nonlinear Models. A Modern Perspective. Boca Raton, FL:Chapman & Hall/CRC.
2. Cook J, Stefanski LA. 1994. Simulation-extrapolation estimation in parametric measurement error models. *J Am Stat Assoc* 89:1314-1328.